MINAR International Journal of Applied Sciences and Technology
ISSN: 2717-8234
Article type: Research Article

Received: 02/11/2021 **Accepted:** 27/11/2021 **Published:** 01/03/2022

STUDY THE EFFECT OF ADDING GLENIUM 51 AND POLYMERIC PLASTICS ON THE MECHANICAL AND PHYSICAL PROPERTIES OF ORDINARY PORTLAND CEMENT

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Abstract

Cement is importance as one of the strategic construction of any civilization depends, and its paramount significance in the construction of building, roads, bridges and infrastructure, which requires the use of cement with special specification and thus the use of polymers as additives to increase the compressive, flexural and tensile strength of the cement used in construction.
Cement producing can possibility with high specification and for multiple uses, some studies be carried out on the use of some available additives in small quantities so as to give the cement high desirable specification in terms of color, compressive strength, tensile and permeability compared to ordinary cement.
This research aims to know the extent to which some of the physical and mechanical properties of cement mortar, such as compressive strength, flexural and tensile strength, are improved upon weight substitution of specific polymeric materials with high efficiency, such as, silica fume .styrene-butadiene, styrene- acrylic in low weight ratio so that it does not add a high economic cost to the production of therequired concrete .for specific uses and sheds light on the effect of different temperatures on the properties where studied in this study .
The study showed that the addition of polymeric materials (Glenium 51, silica fume, styrene –butadiene) with different weight ratio of cement weight at 20°C led to obtaining the highest

http://dx.doi.org/10.47832/2717-8234..106

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compressive strength, flexural and tensile strength at the optimum level to the development and improvement of properties.
Mechanical and physical cement mortar compared to the reference cement free of additives .As for the use of styrene –acrylic, it had a negative effect and led to a decrease in the compressive and tensile strength .especially in the later ages compared to the reference cement.
The optimum ratio of Glenium51 was added to the optimum ratio of each material separately and the mixture was added to the cement mortar at different temperatures(7, 20, 55)°C .The effect of additives on the properties of the cement mortar was studied.
Also, a mixture (Glenium51, silica fume, styrene-butadiene, styrene-acrylic) was added in the optimum proportions for each material to the cement mortar at different temperatures, and this addition led to increase on compressive, flexural and tensile strength at all temperatures compared with reference cement.
Silica fume, styrene-butadiene rubber and styrene acrylic were added separately to the cement mortar without Glenium51, then a mixture of silica fume, styrene-butadiene, and styrene-acrylic was added to the cement mortar .The results showed that the compressive, flexural and tensile strength of cement mortar increase while styrene acrylic decrease these properties when compared with the reference mixture.In addition, the study showed the effect of temperature to the properties of added polymers with cement mortar, All experiments were performed at different temperatures (The temperature which Iraq's climate is exposed under natural conditions.All experiments were conducted at different temperatures (7, 20, 55)°C respectively, to show the effect of degrees on cement compressive strength, which the degree7 represents in winter, 20 in spring and autumn, and 55 in summer.

Keywords: Glenium 51, Polymeric Plastics, Portland Cement.

Introduction

Ordinary Portland cement consists mainly of calcium silicates, aluminum silicates, tetra silicates, and small amounts of sodium and potassium oxide. It is a ceramic material, and the importance of the ceramic material lies in the fact that it has a high melting point and is a good filler and adhesive (1). Cement is applied to the surface of solid objects to make them adhere strongly. It is used in the soft state in the form of a paste, which hardens into concrete upon drying to bind the building materials together (2). Polymers are used with Portland cement to change its physical and mechanical properties. It is a durable and versatile composite material that is used in many industries, most commonly the construction industry. It gives good adhesion strength, high compressive strength, flexural strength, tensile strength and low permeability (3). Polymers have a great impact on the hydration process of Portland cement by forming a continuous polymeric network through the cement mortar, which produces polymer concrete that can be used in maintenance work and the production of sewage pipes, swimming pools and drainage channels, as well as used in the manufacture of bridges and harsh conditions in saline soil by improving the normal properties of cement Especially related to reducing the size of the voids in the mortar to a large extent and increasing the resistance to compression, bending and tensile so that the mortar developed with polymers and concrete developed with polymers became from the construction industry materials prevalent in use in Japan and Europe, which are added in small and limited percentages to the cement mortar (4). The study (5) performed effect of styrene-acrylic emulsion on water consumption, cohesion time, water retention, permeability and mechanical properties of cement mortar. Compressive and bending resistance and the bonding strength between cement particles decreases . Another study by (6) used Metakaolin as a partial substitute for cement mortar to enhance the early mechanical properties and increase the compressive strength in the later ages, as it also worked to reduce the permeability, which leads to resistance to water transfer, the diffusion of harmful ions, resistance to sulfate ion attack, and resistance to germs (7). The researcher also found that adding styrene-butadiene polymer to cement mortar by 10% by weight of cement is the best percentage in improving mechanical properties of hardness, modulus of elasticity, resistance to compression and bending.

Materials and Methods

1. Materials

1.1- Cement:

Ordinary portland cement was used, produced by Badoush expansion factory on 6/9/2020, and it was stored in sealed plastic boxes for the purpose of preventing moisture absorption, provided that the material of the boxes did not react with the cement or affect its properties. All chemical and physical tests were performed according to Iraqi Standard for the year 2019 [10][8] see Table (1,2).

Table (1):The Chemical Composition of the Ordinary Portland Cement

Oxides	Iraqi Standard	Results
In.R	**less**1.5%	**0.85**
MgO	**Less 5%**	**4.04**
SO_3	**2.8% Max for O.P.C*** **2.5% Max for S.P.C****	**2.40**
CaO	-	**62.47**
SiO_2	-	**20.68**
Al_2O_3	-	**5.96**
Fe_2O_3	-	**2.34**
L.O.I	**4% max**	**1.35**
Fr.L	-	**1.48**
L.S.F	-	**91.29**
C_3S	-	**40.75**
C_2S	-	**28.55**
C_4AF	-	**7.18**
C_3A	-	**11.80**

*O.P.C: Ordinary Portland cement **S.P.C: Sulphate Portland cement

Table (2): The physical properties for the Portland Cement

Physical tests	**Iraqi standard specification**	**Results**
Specific gravity	-----	3.12
Blain's finess (cm^2/gm)	250for S.P.C ≤ ≥ 280 for O.P.C	313.5
Initial setting time (min)	45min ≤	145
Final setting time (hour)	≤10 hours	3:05
Expansion: Autoclave	≤0.8%	0.06
Compressive strength (2days)	10 N/mm^2≤	20.00
Compressive strength(28days)	N/mm^2 32.5 ≤	45.25

1.2- Fine aggregate: Turkish sand was used which is imported according to the European standard EN 196-1/ 2016 [11] from the Turkish company Limak, with plastic bags with weights of 1350 ± 5 g. The moisture content is less than 0.2%. The humidity is determined from the decrease in mass. For the sample after putting the sand in Oven which temperature is (110-105) C° for two hours, expressed as a percentage of the dry mass[9]. the gradation of sand grains is shown in Table (3).

Table (3) The Sieve Size Of Sand Anaylsis

Sieve Size (mm)	Residue(gm)
2.0	0
1.6	7±5
1.0	33±5
0.5	67±5
0.16	87±5
0.008	99±1

1.3- Water used in cement mortar:

The water used in cement mortar must be free of fatty, acid, alkali and plant materials, and it must be suitable for civilian uses

1.4-Glenium 51: is an innovative admixture based on modified polycarboxylic ether (PCE) polymer,it is complied with EN 934 – 2[12] and is compatible with all types of cement ,Figure (1) explain the chemical structure of Glenium51, Table (4) contains the properties of the polymer

Table (4): The properties of Glenium 51

Properties	**Datum**
Chemical Structure	poly carboxylic ether
Color	Brown Liquid
Specific gravity at 20 C°	1.10±0.03 g/cm^3
PH- value	7.0±1
Alkali content %	≤ 3.00
Chloride content %	≤ 0.10
Corrosion behavior	Contains only components according to BS EN 934-1:2008 ,Annex A.1
Compatibility	It is suitable for use with all types of cement, Silicafume,Fly-ash,slag
Water reduction	≥ 112% of Reference mix
Increase in consistence	Increase of ≥ 120mm from initial slump or ≥ 160mm from intial flow
Retention of consistence	At 30 mins ≥ Reference mix at initial
https://www.master-builders-solutions.com	

***The properties at 20C°, Relative Humidity 50%**

1. **5-Silica fume (SF):** It was supplied from(BASF) -the properties explained in the table (5).It used with dosage(0.11-0.88)% from weight of cement in this research.

Table (5) The Physical properties of Silica fume

Physical properties	**Value or Description**	**ASTM C1240** [10]
State	**Nano powder**	**Sub-micron powder**
Partical size	**Amorphous**	**-**
Density	**Kg/l 0.7-0.55**	
Color	**Grey**	
Allowed Dosage	**(5-15)% by weight of cement**	
Compatibility	**It is suitable for use with all types of cement,cementation materials and superplastizer**	
Blaine	**gm / cm² 3600**	
Surface area	**cm²/gm 200000**	
https://www.master-builders-solutions.com		

1.6- Styrene Butadiene Rubber: SBR: It is designed to be used with cement mortar and has such pure chemical-mechanical stability and produces very good compressive and flexural strength[11], The table (5) shows the polymer properties

Table (5) The properties of SBR

1	Chemical structure	Styrene-Butadene copolymer
2	Characterristics	Waterborne xSBR dispersion
		Plasticizer free
+		Solvent free
3	Specification	Solid content:47-49(%)
	PH	8.5-9.5%
	Max. Viscosity	300 mPa.s
4	Dispersion properties	
	Appearance	Milky-white emulsion
	Particle size	175 nm ca.
	www.eocgroup.com info@eocgroup.com	

1.7- Styrene Acrylic Rubber: SAR

Acrylic polymers have been used to modify Portland cement compounds for more than 40 years. The term acrylic refers to a group of materials that have a similar chemical structure but have a wide range of properties. The styrene-acrylic copolymer plays a major role in the family of acrylic polymers used in cement mortar[12].

2.Methods: Used Mixtures:

2.1.The mixture used in the test of compressive and flexural strength.

The ratio (3: 1) (cement: sand) and water / cement ratio is equal to (0.5) is adopted in specimens preparation to test the compressive and flexural strength , and all physical and chemical tests were conducted at the Badoush Laboratory, the temperature was established at 20C° through the ponds in an amazing oven. Then, evaluated the compressive strength and flexural at (28, 2) day.

2.2. The mixture used in the test of tensile strength:

The mixture adopted (3: 1) (cement: sand) and water / cement ratio is equal (0.45) and all the mixture carried out in the material laboratory in the Department of Civil Engineering / University of Mosul for the period between March and September. the temperature was established at 20C° through ventilated oven. Then, measurement the Tensile strength at (2, 28) day. It included a series of experiments:

The first series: Adding Glenium 51 by different percentage from cement weight with reducing water content as added Glenium 51 to obtain high compressive and flexural strength of cement and high tensile strength at the optimum value Glenium 51.

The Second Series: Addition the Silica fume alone to the cement mixture without Glenium 51 and keeping a fixed water / cement ratio. Then, study the effect of this material in cement properties.

The third series: Addition the optimum value of Silica fume obtained from the second series to the optimum value of the Glenium 51 obtained from the first series and add the mixture to cement mortar. Then, study the effect of this materials on cement properties.

3. Method of mixture:

3.1. Mixing method for testing the compressive and flexural strength of cement moetar:

Cement mortar was mixed according to Iraqi specification No. (5) /2019 [10] using mechanical mixer and the standard sand and cement are placed in the mixer's bowl and slowly mixing at the slow speed for 30 seconds. Then, increases to the high speed for 60 seconds and stops mixer for 90 seconds. After that, removing what all precipitated on the walls of the bowl by rubber and returned to the mixture for homogeneity.

3.2. Mixing method for testing the tensile strength of cement moetar

Cement mortar was mixed according to (ASTM C150) /2015[13] ,Dry material mixed for 60 seconds then added Glenium 51 at percentage of cement weight after reducing water content as much as the amount of Glenium 51 added and added aqueous solution (Glenium 51 + water)to the dry materials within 30 seconds and mixing the mixture for 90 seconds for the purpose of homogenization.

3.3. Molds Used:

1. Molds used in compressive and flexural strength of cement mortar:

The prisms with a dimension of (40 * 40 * 160) mm were prepared for compressive and flexural strength. The inner surface of the molds is lubricated after tightening their parts with a thin layer of mineral oil to prevent cement mortar from sticking to the molds , The molds have been filled with half the amount of cement mounces in a thin layer and sucked by vibrator for 60 seconds. Placed in box with relative humidity 95% and 20±1 C° for 24 hours. Then, opening the molds continue to be treated in water at 20 ± 1C° for (2, 28) Day. All tests done according of Iraqi Specification No. (5) /2019[10]

2. Molds used in tensile strength of cement mortar:

Iron brackets were used according to ASTM C150 /2015. The inner surface of the brackets was lubricated with a thin layer of mineral oil to prevent cement mortar from sticking to the brackets and filling the brackets with one layer cement and compression by the thumbs (6) times from the top layer and then turn the bracket and repeat the process again and then leave 24 hours at room temperature before opening the bracket.

Process of treatment: Two methods used to treat cement molds

1- Continuous standard treatment with water. Then, immersion compressive, flexural, and tensile prisms in a special tank after opening them from the molds till to be tested.The models of each group are isolated from other group models. The salt concentration in the water was fixed by adding water to the basin to compensate for the evaporated water and fixed at 20 C°.

2- The molds were treated at room temperature after the opening of the molds until they were tested after being taken out of the refrigerator at 7 C° and in the oven at 55C°.

3- Tests:

1- Compressive strength of cement mortar:

The SERVO PLUS / EVOLUTION machine was used which have 400 kg and 300KN capacity according to Iraqi specification / 2019. The Prisms were tested at (2, 28) day in 6 halves of prism per each mixture.

2-Flexural strength of cement mortar:

The same machine in (1) is used to test flexural strength and according to Iraqi specification / 2019 The prisms were tested at (2, 28) day in 3 prisms per each mixture.

3- Tensile Strength of Cement Mortars

Uses machine of tensile strength type (ULITEST), USA origin have a capacity of 100 tons and speed loaded 40 kg / 10 seconds to measure the strength of tensile according to ASTM C 150 / 2015[18]at (2, 28) day in three brackets per mixture.

Results and Discussion

1- Effect of addition of Glenium 51 on compressive,Flexural and Tensile strength of cement mortar at 20 °C, 7 °C, 55 °C

% Glenium	Temp.C°	Compressive strength (Mpa)		Flexural strength (Mpa)		Tensile strength (Map)	
		2days	28days	2days	28days	2days	28days
0.00	20	20.00	45.25	10.31	22.23	1.7	3.3
	7	10.46	30.20	6.26	15.27	1.50	2.59
	55	14.00	32.15	8.11	18.36	1.59	2.62
0.11	20	20.39	45.80	11.96	22.50	1.8	3.36
0.22	20	22.14	46.00	13.30	22.55	1.86	3.40
0.33	20	22.68	47.24	14.60	22.90	1.89	3.42
0.44	20	25.68	48.24	16.86	23.28	2.07	3.45
0.55	20	28.34	52.88	17.00	23.66	2.12	4.00
0.66	20	34.25	54.41	18.10	24.80	2.97	4.60
	7	12.20	37.60	9.47	19.91	12.10	23.41
	55	17.37	38.60	12.10	23.41	2.67	2.88
0.77	20	27.02	50.09	14.30	21.66	1.79	2.12
0.88	20	10.39	23.28	10.00	15.80	1.2	1.40

2- The effect of adding silica fume to the compressive,Flexural and Tensile strength of cement mortar at (20,7,55) C°

Table (7) The effect of adding Silica fume in the compressive,Flexural &Tensile strength to the cement mortar at 20C,7C°,55C°

% Silicafume	Temp. °C	Compressive strength (Mpa)		Flexural strength (Mpa)		Tensile strength (Map)	
		2days	28days	2days	28days	2days	28days
0.00	20	20.00	45.25	10.31	22.23	1.7	3.3
	7	10.46	30.20	6.26	15.27	1.50	2.59
	55	14.00	32.15	8.11	18.36	1.59	2.62
0.11	20	22.80	46.23	11.80	22.66	1.88	3.65
0.22	20	23.22	47.00	13.35	22.96	2.35	3.80
0.33	20	25.11	47.33	14.65	23.55	2.60	4.19
0.44	20	27.20	49.73	17.10	25.13	2.85	4.37
	7	13.95	36.26	11.60	16.77	11.30	21.09
	55	16.80	38.06	11.30	21.09	2.35	3.20
0.55	20	23.05	46.60	16.80	23.00	2.51	3.72
0.66	20	21.83	46.22	16.00	22.62	2.47	3.36
0.77	20	20.80	45.11	15.63	22.53	2.11	2.90
0.88	20	20.09	43.82	13.50	20.55	2.04	2.50

2- The effect of adding Styrene-Butadene Rubber to the compressive strength of cement mortar at (20,7,55) C°

Table (7) The effect of adding Styrene-butadene to the compressive,Flexural &Tensile strength to the cement mortar at 20C,7C°,55C°

% SBR	Temp.C°	Compressive strength (Mpa)		Flexural strength (Mpa)		Tensile strength (Map)	
		2days	28days	2days	28days	2days	28days
0.00	20	20.00	45.25	10.31	22.23	1.7	3.3
	7	10.46	30.20	6.26	15.27	1.50	2.59
	55	14.00	32.15	8.11	18.36	1.59	2.62
0.11	20	26.60	48.07	13.71	26.17	3.02	3.88
	7	16.21	33.08	8.60	17.80	1.90	2.72
	55	18.18	39.01	9.17	20.17	1.73	2.94
0.22	20	26.40	47.60	11.8	23.18	2.56	2.99
0.33	20	24.30	46.88	11.18	22.87	2.46	2.71
0.44	20	23.70	46.77	10.25	22.14	2.28	2.43
0.55	20	22.80	46.63	10.42	21.83	1.99	2.35
0.66	20	21.20	45.80	10.20	21.58	1.87	2.30
0.77	20	21	45.66	10.13	21.48	1.79	2.22
0.88	20	20.54	45.10	9.75	19.25	1.52	2.07

2- The effect of adding Styrene-Acrylic Rubber to the compressive,Flexural and Tensile strength of cement mortar at (20,7,55) C°

Table (8) The effect of adding Styrene-Acrylic to the compressive,Flexural &Tensile strength to the cement mortar at 20C,7C°,55C°

% SBR	Temp.C°	Compressive strength (Mpa)		Flexural strength (Mpa)		Tensile strength (Map)	
		2days	28days	2days	28days	2days	28days
0.00	20	20.00	45.25	10.31	22.20	1.70	3.30
	7	10.46	30.20	6.26	15.27	1.50	2.59
	55	14.00	32.15	8.11	18.36	1.59	2.62
0.11	20	17.90	43.59	12.55	25.11	2.46	4.11
	7	7.15	26.18	4.05	14.74	0.85	1.87
	55	9.13	25.95	4.91	16.06	1.13	2.11
0.22	20	17.55	42.75	11.95	24.55	2.40	3.91
0.33	20	16.90	41.61	11.25	23.40	2.36	3.72
0.44	20	16.20	40.97	10.88	22.80	2.22	3.63
0.55	20	16	40.52	10.60	22.50	2.02	3.54
0.66	20	15.77	40.22	10.56	20.85	1.81	3.41
0.77	20	15.25	39.11	10.35	20.44	1.71	3.25
0.88	20	14.80	39.00	10.41	20.75	1.68	2.90

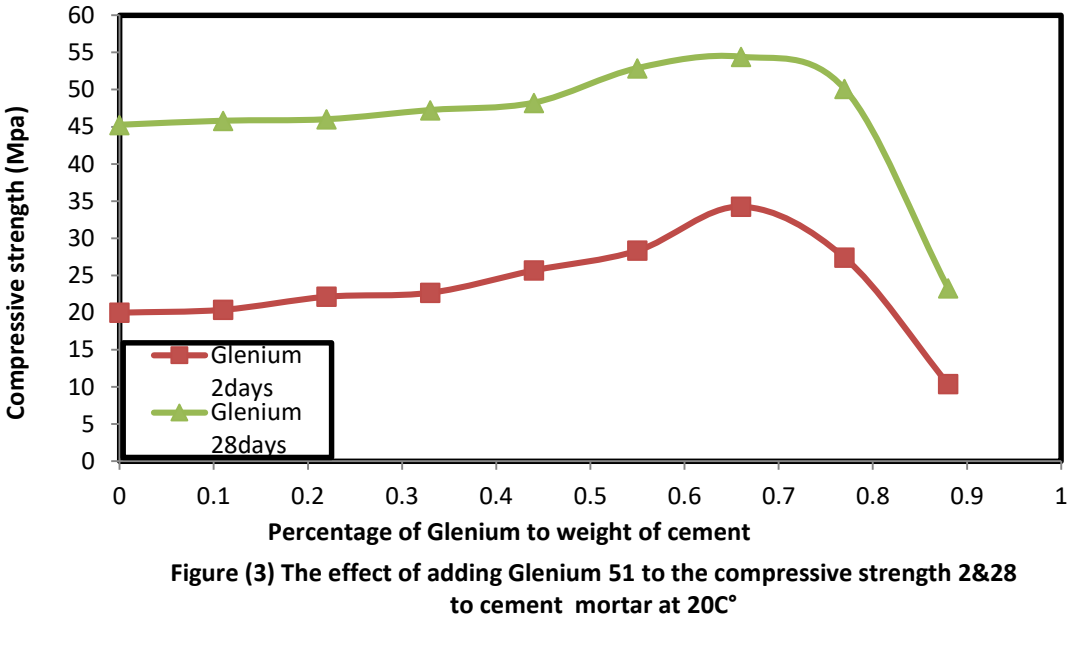


Figure (3) The effect of adding Glenium 51 to the compressive strength 2&28 to cement mortar at 20C°

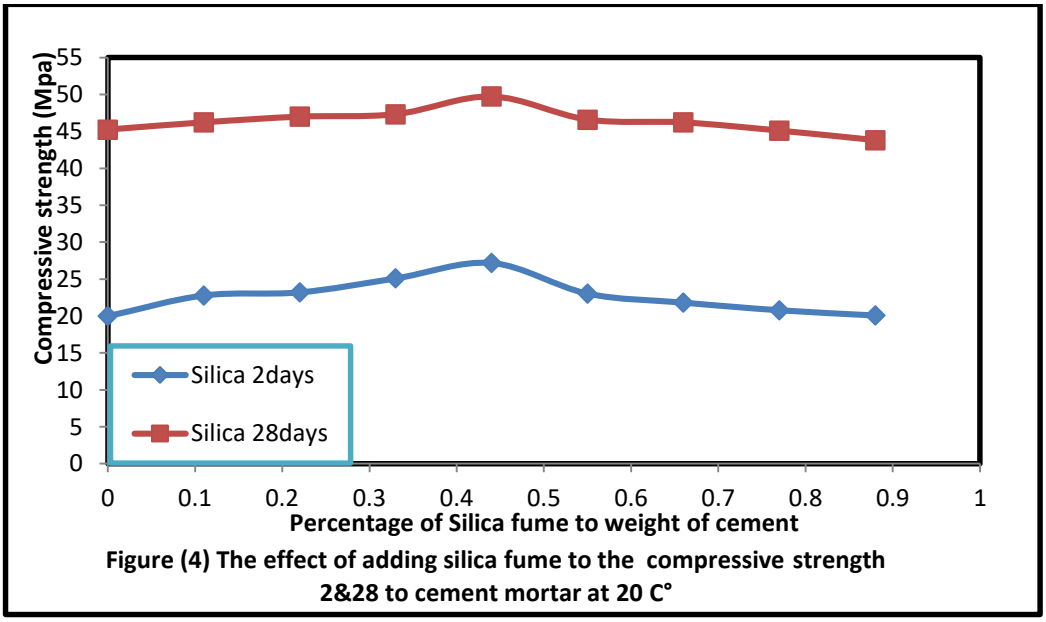


Figure (4) The effect of adding silica fume to the compressive strength 2&28 to cement mortar at 20 C°

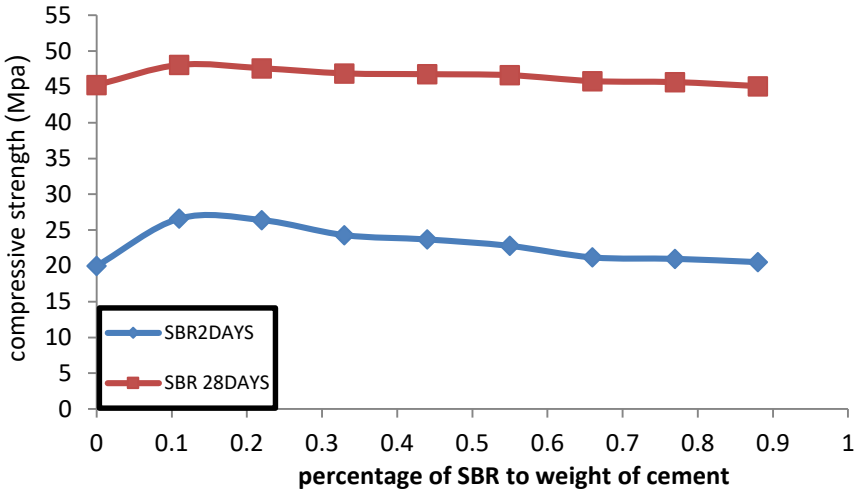


Figure (4) The effect of adding SBR to compressive strength 2&28days on cement mortar at 20C°

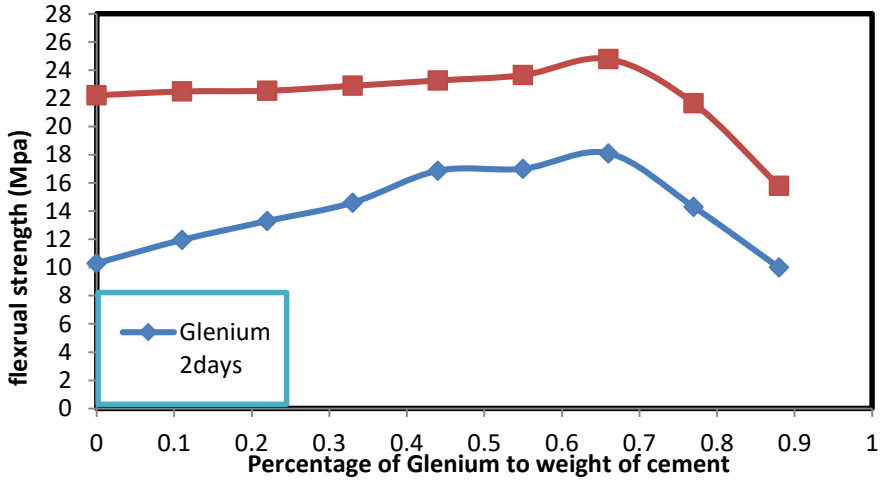


Figure (5) The effect of adding Glenium 51 to the flexrual strength of cement mortar for 2&28days at 20 C°

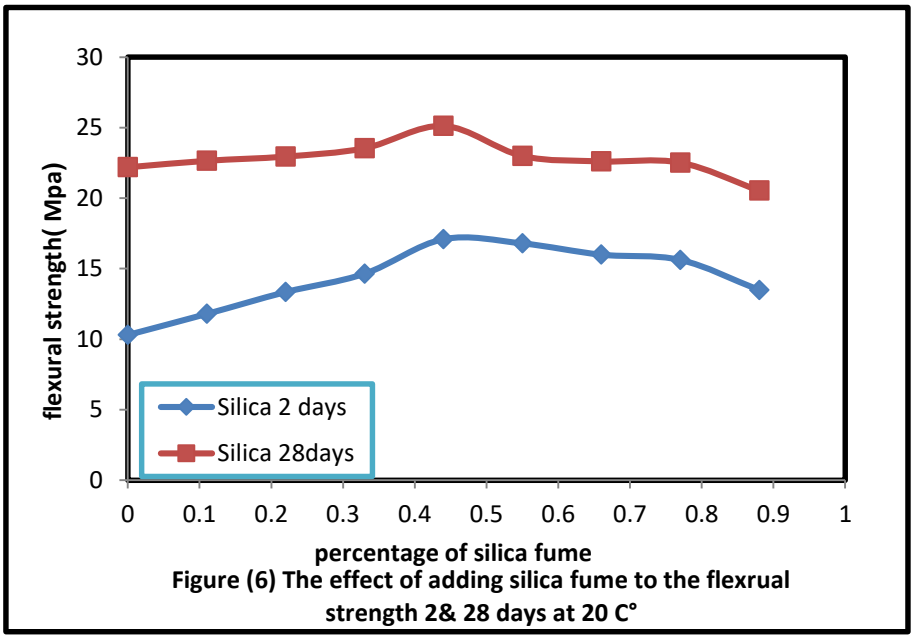
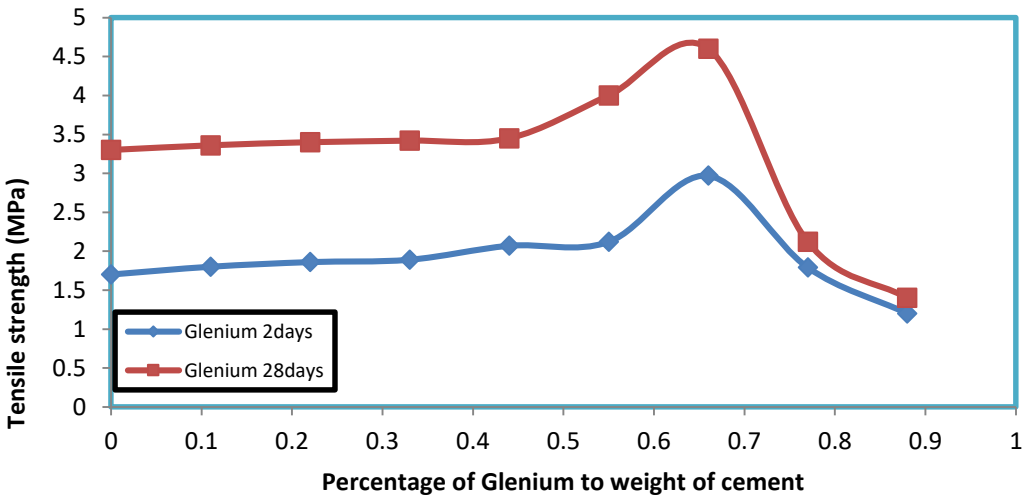
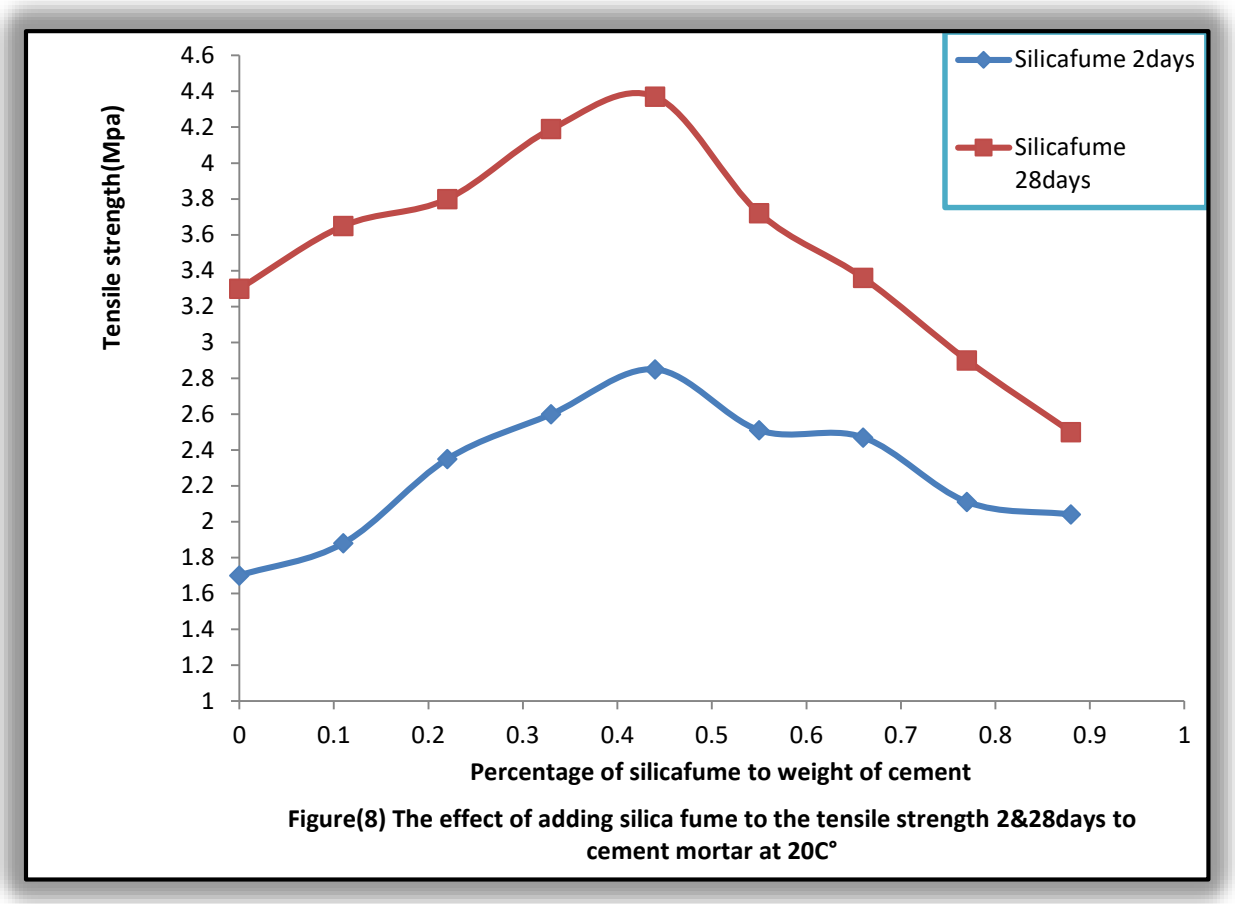


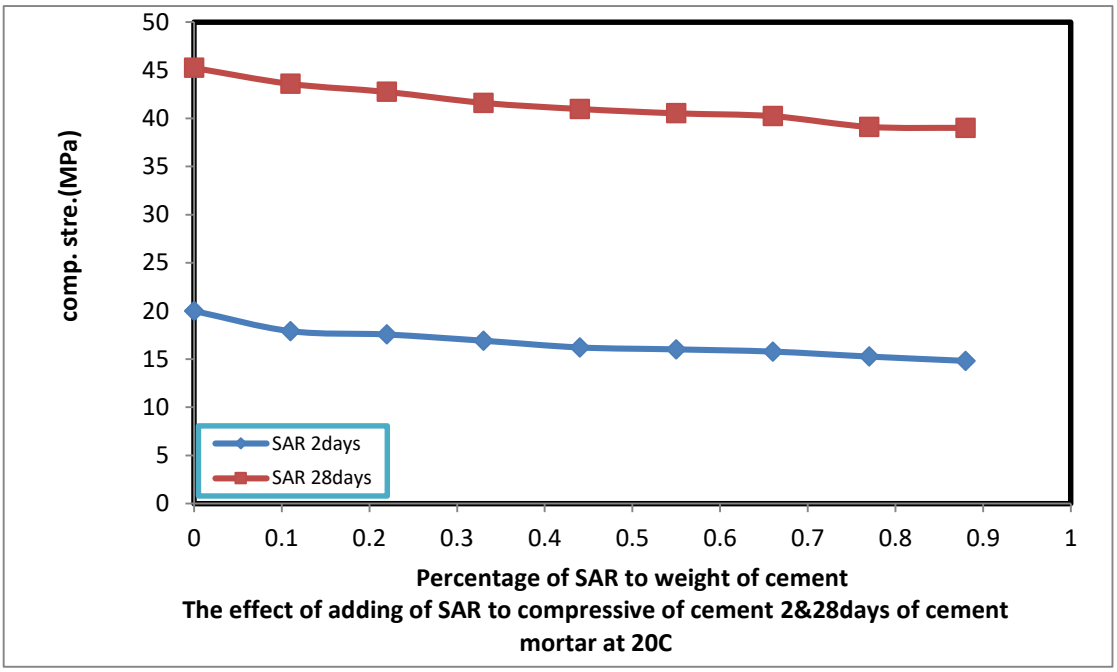
Figure (6) The effect of adding silica fume to the flexrual strength 2& 28 days at 20 C°



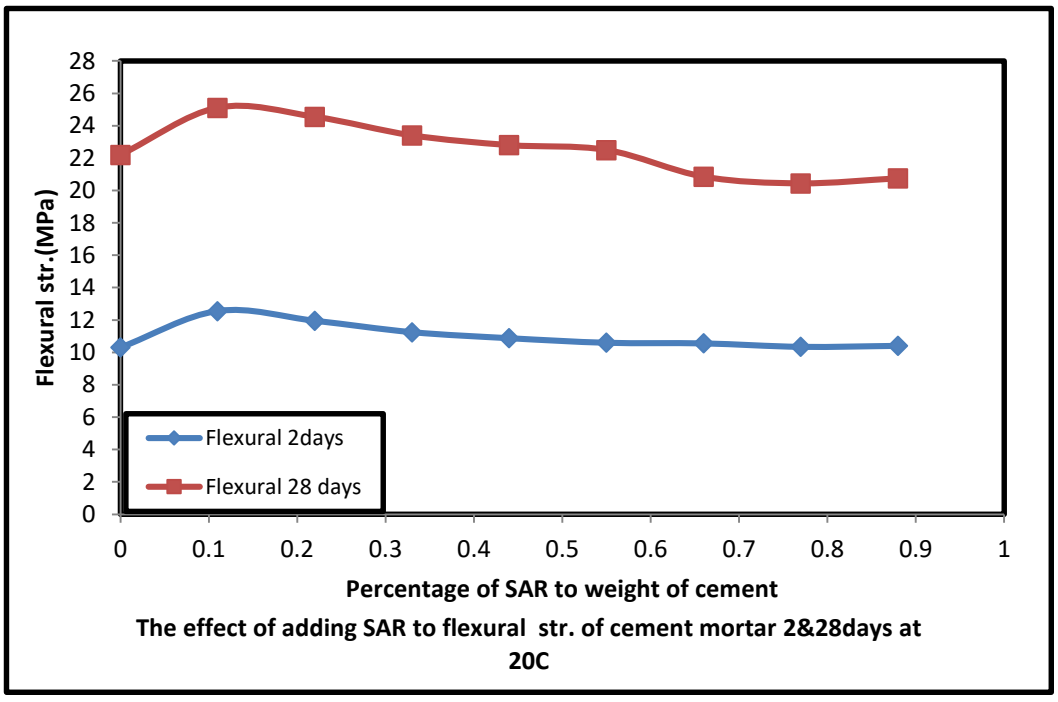
Figure(7) The effect of adding Glenium 51 to the tensile strength 2&28days to the cement mortar at 20C°



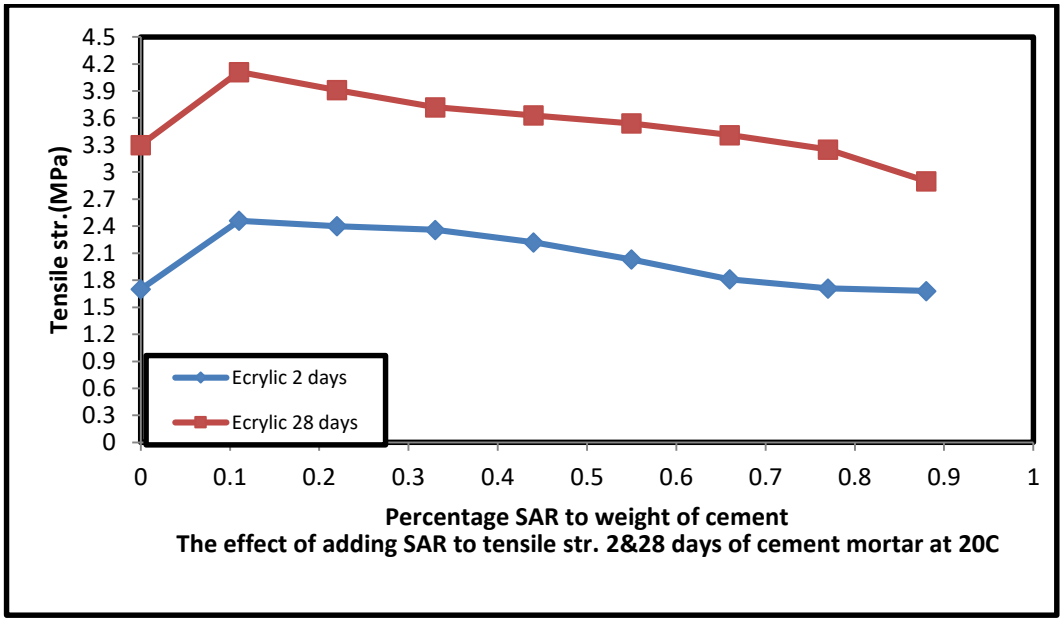
Figure(8) The effect of adding silica fume to the tensile strength 2&28days to cement mortar at 20C°



The effect of adding of SAR to compressive of cement 2&28days of cement mortar at 20C



The effect of adding SAR to flexural str. of cement mortar 2&28days at 20C



Effect of temperature on the compressive, bending and tensile strength of cement mortar:

1-Effect of temperature on Glinium 51:

It was found that the compressive strength of the models that were treated at a temperature of (20°C) is higher than the compressive strength of the models that were treated at a temperature of (55°C), and in turn, it is higher than the compressive strength of the models that were treated at a temperature of (7°C), as shown in Figure (1) and (2) where the compressive strength of samples containing Glinium 51 at 20° C was (34.25, 56.41) MPa at (2, 28) days, respectively, while the compressive strength of models containing Glinium 51 at (7° C)) (12.20, 37.60) MPa and at 55 °C(17.37, 38.60) MPa. The same applies to bending and tensile strength when compared to previous studies (14), where the study showed the kinetics of cement hydration in the presence of (0.5%) of Glinium 51 and under the influence of increasing temperature by x-rays for models aged (24) hours. clinker and raising the temperature from (20°C to 40°C) accelerates the hydration process of cement components at the beginning of hardening (14).

2- The effect of temperature on the behavior of silica dust in cement mortar:

The results recorded that the compressive strength of the models that were treated at a temperature of (20 ° C) is higher than the compressive strength of the models that were treated at a temperature of (55 ° C), and in turn, it is higher than the compressive strength of the models that were treated at a temperature of (7 ° C), as shown in the figure (3)

Where the compressive strength of models containing silica dust at (20°C) was (27.20, 49.73) MPa with an age of (2.28) days, respectively, while the compressive strength of models containing silica dust at (7°C) was (13.95, 36.26)) MPa, while the models treated at (55°C) (16.80, 38.06) MPa, and the same applies to bending and tensile strength[15,16]..

3- Effect of temperature on the behavior of styrene butadiene in cement mortar:

The results elucidated that the compressive strength of the models that were treated at a temperature of (20°C) is higher than the compressive strength of the models that were treated at a temperature of (55°C), and in turn, the compressive strength of the models that were treated at a temperature of (7°C) as shown in the figure ((4), (5) and (6), where the compressive strength of samples containing styrene-butadiene at a degree of (20°C) was

(26.60, 48.07) MPa at the age of (2, 28) days, respectively, while the compressive strength of samples containing SBR was At (7 °C) (16.21, 33.08) MPa and at (55 °C) (18.18, 39.01) MPa. The same applies to resistance to bending and tensile strength[17]. That the rapid initial hydration is with products with a weaker physical structure and that this structure has many pores and leads to a lower compressive strength due to slow hydration The effect of temperature on the flexural and tensile strength of the cement mortar is the same as on the compressive strength [18].

4- Effect of temperature on the behavior of styrene-acrylic in cement mortar:

This study indicated that the compressive strength of the models that were treated at a temperature of 20 ° C is higher than the compressive strength of the models that were treated at a temperature of (55 ° C), and in turn, the compressive strength of the models that were treated at a temperature of (7 ° C), as shown in the figure ((7), (8), and (9), where the compressive strength of models containing styrene-acrylic at a degree (20°C) was (17.9,43.59) MPa at (28.2) days, respectively, while the compressive strength of models treated was at a degree of 7. °C (7.15, 26.18) MPa at an age of (2,28) days, respectively, at 55 °C (9.13, 25.95) MPa.

The same applies to resistance to bending and tensile strength. When styrene acrylic was added to Glenium 51, the compressive strength of samples treated at 20°C (23.99, 47.86) MPa, while those treated at 7°C

(20.98, 35.69) MPa and (55°C) were (21.45, 40.85) MPa at (2.28) days old, respectively[19,20].

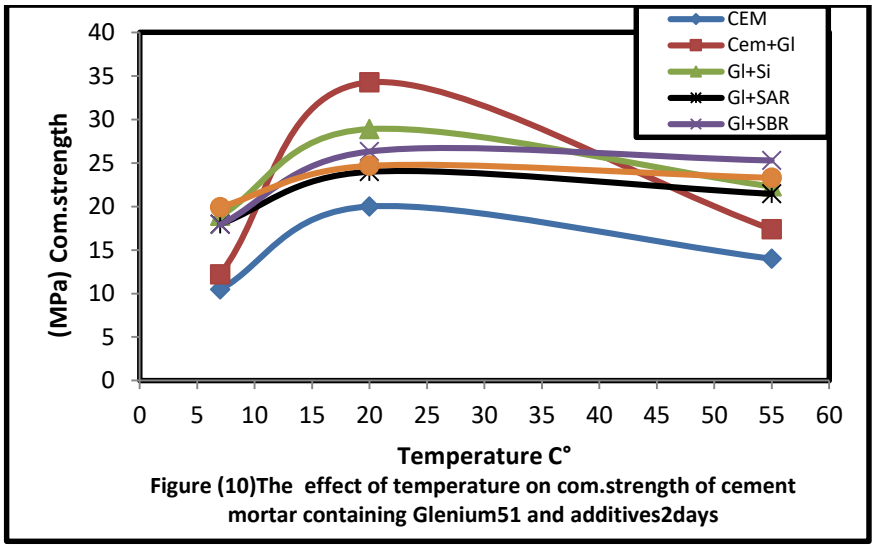
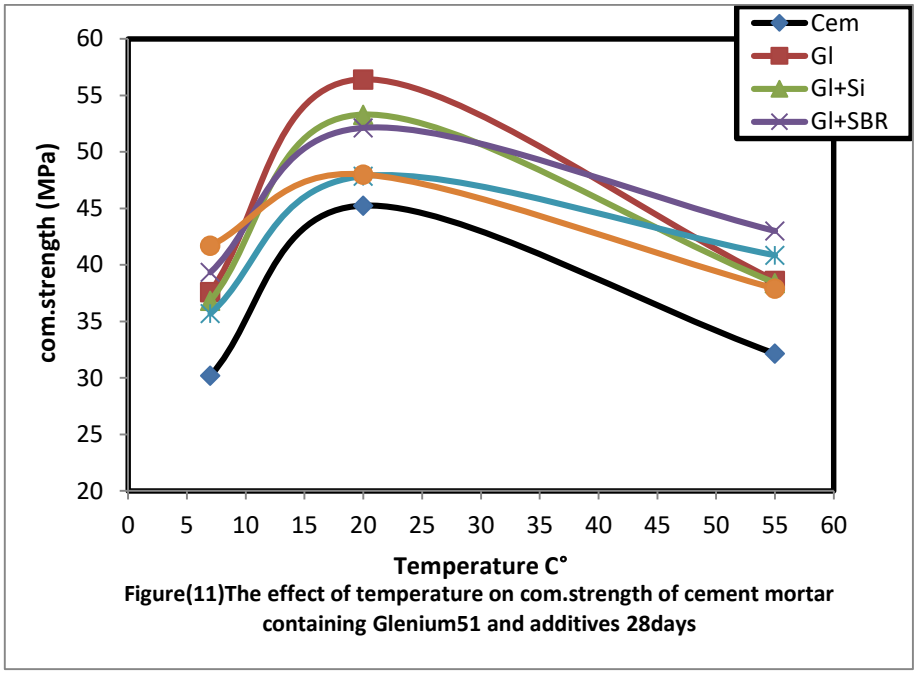


Figure (10)The effect of temperature on com.strength of cement mortar containing Glenium51 and additives2days



Figure(11)The effect of temperature on com.strength of cement mortar containing Glenium51 and additives 28days

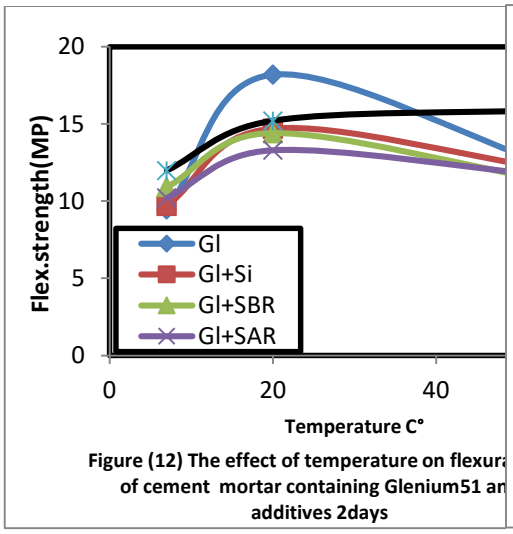


Figure (12) The effect of temperature on flexur
of cement mortar containing Glenium51 ar
additives 2days

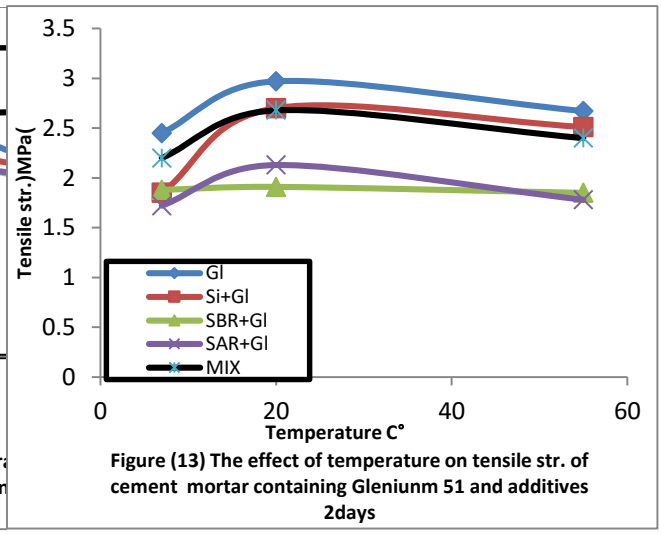
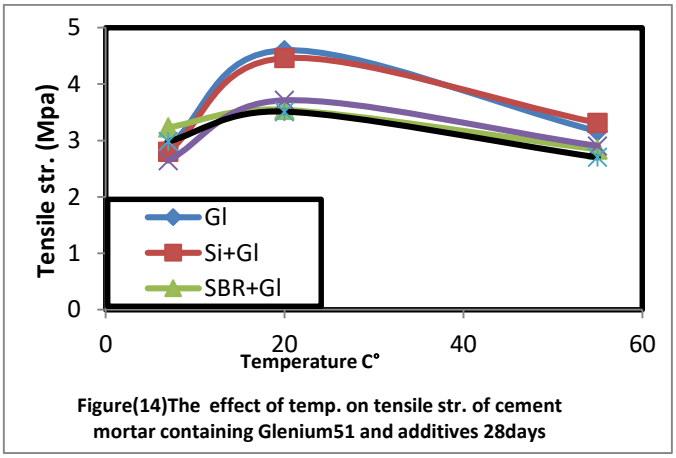


Figure (13) The effect of temperature on tensile str. of cement mortar containing Gleniunm 51 and additives 2days



Figure(14)The effect of temp. on tensile str. of cement mortar containing Glenium51 and additives 28days

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